TITLE OF THE INVENTION

INSPECTING METHOD, INSPECTING SYSTEM, AND METHOD FOR MANUFACTURING ELECTRONIC DEVICES

BACKGROUND OF THE INVENTION

The present invention relates to an analyzing unit, an inspecting system and a manufacturing method using the inspecting system which are applied to the production line of electronic devices and the like, and particularly to an analyzing unit, an inspecting system and a manufacturing method using the inspecting system, which efficiently classify images obtained as a result of inspection to thereby shorten an analysis time for failure and to enable enhancement of manufacturing efficiency and rapid yield ramp-up.

An electronic device, typically a semiconductor, is formed by repeating a plurality of processing steps of exposure, development, etching and the like on a wafer substrate. On the other hand, for wafers processed in a certain processing step out of the plurality of processing steps, information on the position, size, number, category, etc. of foreign matters adhered to the wafer and appearance failures, and information on processing dimensions of workpieces (hereinafter generally referred to as defects) are collected by a foreign matter inspecting apparatus, an optical visual inspection apparatus, and an inspecting

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apparatus such as SEM, if necessary. In Monthly Publication, "Semiconductor World", 1996.8, pp 88, 99 and 102 it is described that all the inspecting data are normally sent from the inspecting apparatus to the analyzing system through a network for control and analysis.

Further, in the plurality of processing steps, an electronic microscope or the like is used to specify the cause of occurrence of the defects to obtain a defect image and perform the classifying operation on the basis of shapes and sizes of the actual defects. This classifying operation is carried out visually on the screen of a personal computer or the like, defect images are sampled on the basis of the size, the shape and the like of the defects, and then classified into a group of similar defects. It is noted that for defects to be sampled, several numbers of defects per wafer are manually determined referring to the distribution of defects a wafer map. Recently, several hundreds of defect images per hour are automatically obtained by an automatic defect review (ADR) of defect images. Anyway, the number of samples images handled has a tendency to increase.

SUMMARY OF THE INVENTION

However, a user interface (image display) in the classifying operation is not sufficiently reviewed. Therefore, it is difficult to efficiently classify a number

of detected images, not only requiring an extensive time for the classifying operation but having a tendency to lower the analysis accuracy also. The number of images detected in the future is expected to increase, and it has been an important problem to enhance a convenience in the classifying operation to shorten the classifying operation time. Further, there was a possibility that the requirement of long terms for the classifying operation brings forth a delay of a feedback operation and a great hindrance to a yield of the production line.

It is an object of the present invention to shorten the analysis time and enhance the analysis accuracy by improving the user interface. Further an object of the invention is to thereby enhance the yield of the production line.

For achieving the aforementioned objects, according to the present invention, there is provided an inspecting system comprising an analyzing unit, said analyzing unit including an image detection device for photographing a plurality of images in a workpiece; a storage means for storing detected images detected by said image detection device; and a display means having a first area for displaying a plurality of detected images stored in said memory means and a plurality of second areas for classifying said detected images according to features of said detected images; wherein said plurality of detected

images can be moved on a screen from said first area to said corresponding second areas to classify said plurality of detected images in said second areas.

Further, there is provided an analyzing unit comprising a storage means for storing a plurality of detected images; and a display means having a first area for displaying a detected image stored in said storage means and a plurality of second areas for classifying said detected images according to features of said detected images; wherein said plurality of detected images can be moved on a screen from said first area to said corresponding second areas to classify said plurality of detected images in said second areas.

Further, there is provided a method for manufacturing an electronic device wherein use is made of a manufacturing apparatus for processing a workpiece to be an electronic device; an inspecting apparatus for inspecting the workpiece processed by said manufacturing apparatus; and an analyzing unit including an image detection device capable of photographing an image of said workpiece, a storage means for storing detected images detected by said image detection device, and a display means having a first area for displaying a detected image stored in said storage means and a plurality of second areas for classifying said detected images according to features of said detected images, whereby said plurality of detected images can be

moved on a screen from said first area to said corresponding second areas to classify said plurality of detected images in said second areas; wherein the production line having said manufacturing apparatus arranged thereon is controlled using information obtained from said analyzing unit to process the workpiece.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view showing a defect image display and classification function showing one embodiment of the present invention;

FIG. 2 is a system constitutional view showing one embodiment of the present invention;

FIG. 3 is a classification operation processing flow chart showing one embodiment of the present invention;

FIG. 4 is a view showing a data example before classification in one embodiment of the present invention;

FIG. 5 is a view showing a display screen before classification in one embodiment of the present invention;

FIGS. 6(a) and 6(b) are views showing a display screen during classification in one embodiment of the present invention;

FIGS. 7(a) and 7(b) are views display screen during classification in one embodiment of the present invention;

FIG. 8 is a view showing a display screen during classification in one embodiment of the present invention;

FIG. 9 is a view showing a display screen during classification in one embodiment of the present invention;

FIG. 10 is a view showing a display screen after classification in one embodiment of the present invention;

FIG. 11 is a view showing a data example after classification in one embodiment of the present invention;

FIG. 12 is a classification operation processing flow chart showing one embodiment of the present invention;

FIG. 13 is a view showing a display screen during classification in one embodiment of the present invention;

FIG. 14 is a view representative of functions used for automatic classification in one embodiment of the present invention;

FIG. 15 is a view showing a display screen during classification in one embodiment of the present invention; and

FIG. 16 is a view showing a defective classification result analyzing function in one embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

FIG. 1 is a view showing a display and classification function of a detected defect image on a PC

(Personal Computer) display screen equipped with an analyzing unit.

In the figure, reference numeral 101 designates a display screen of PC. Numeral 151 designates an unclassified image display area for displaying an image not subjected to classification operation out of detected defect images. Numeral 102 designates detected individual defect images in the unclassified image display area 151. Numerals 152 to 155 designate classification areas for classifying defect images. Numerals 103 to 106 designate defect images having corresponding features to the classification areas 152 to 155 respectively. For example, numerals 103, 104, 105, and 106 designate a defect image having a white and round defect feature, a black and round defect image, an elongated defect image, and a large defect image, respectively. Numeral 107 designates a processing button for executing a preassigned function. As will be understood from FIG. 1, the present embodiment is designed so that a classification area for classifying defect images is provided on a screen, and typical images and classified images are displayed on the screen. Therefore, in the case where the detected defect images are classified, even if a number of defect images having complicated shapes are displayed, a user will suffice to merely move the defect images to the optimal classification area indicative of similar visual features, thus enabling carrying out the

classification operation easily and quickly. In particular, since the classification operation can be carried out by a drag and drop using a mouse or the like on the screen, the classification operation can be done while looking at all the defect images on the display screen, the classification operation can be performed while relatively comparing all the defect images, and its operativeness is excellent. The detailed operation will be described later.

FIG. 2 is one mode of a system constitutional view for realizing the present invention.

In this figure, reference numeral 201 designates an image detecting device; 202 a storage unit; 203 and 204 display/analyzing devices; 205 a system control computer; and 201 a network such as LAN in a factory. The storage unit 202 either may be connected to an image detecting device, or may be connected to a separate apparatus on the network, for example, the image detecting device 201. It is noted that the display/analyzing function as shown in FIG. 1 can be mounted on the image detecting device 201, or mounted on the computer connected to the image detecting device 201, or mounted on the display/analyzing device 204 in an office or the like physically away therefrom, but in the present embodiment, the function thereof is mounted on the display/analyzing device 203. A plurality of image detecting devices 201 may be installed, though not shown, in which case the system control computer 205 is able to

distribute the feature set and adjusted to each image detecting device 201. Thereby, in classification at each image detecting device 201, the features can be standardized. The setting and adjustment of the features will be described later.

FIG. 3 is a classification operation processing flow in the inspection system shown in FIG. 2.

First, the image detecting device 201 detects 100 to 300 defect images in a single wafer (Step 300). The detected defect images are temporarily stored in a memory of the image detecting device 201 with a defect location coordinate corresponded to its defect image on the wafer (Step 301).

Next, the image detecting device 201 calculates the features of the detected images stored in the memory (Step 302). For example, it calculates numerical values that the size, color, shape and the like of the detected images have.

When the features of the detected images are calculated, a data format as shown in FIG. 4 is generated, which is transmitted to the storage unit 202 (Step 303). The data format shown in FIG. 4 is constituted so that coordinate of defects, date and time of operation, the name of the corresponding detected image, features, and classification categories showing information in the case where the detected images are classified can be described. In this case, since the classification operation of

detected images is not yet carried out, information showing unclassification is described in the classification category. Alternatively, it may be constituted so that inspection results of detected images or the like are directly transmitted to the storage unit 202, and the storage unit 202 carries out calculation of the features and production of the data format. Further, alternatively, it may be constituted so that the image detecting device 201 also carries out the calculation of features of the detected images.

In this manner, image information, which includes the information, such as the image itself, position, detecting condition, feature and category, collected every wafer are sequentially stored in the storage unit 202.

Now, in the case where a user carries out the classification for the image information, first, the display/analyzing device 203 obtains the image information shown in FIG. 4 from the storage unit 202 (Step 304). For example, identification information such as wafer numbers to be subjected to the classification operation is input into the display/analyzing device 203, and corresponding image information is obtained from the storage unit 202.

The display/analyzing device 203 which has obtained the image information displays the detected defect images on the unclassified image display area 151 (Step 305). FIG. 5 shows its display example, in which 20 defect images

having various shapes, sizes, and colors are displayed.

Next, there is prepared a classification area 152 for classifying defect images as shown in FIG. 6(a) (Step 306). In this preparation, a classification area displayed on the display screen is related to a category of the area as shown in FIG. 6(b). That is to say, each area in the display screen is characterized, and the category (features) related as in FIG. 6(b) is imparted to the defect image classified into the area. In FIG. 6(b), the fact that the category is white is imparted to defect images positioned at area coordinates (000160, 000020)(000220,000100) of the classification area 152. However, in FIG. 6(b), since the defect images are not moved on the display screen from the unclassified image display area 151 to the classification area 152 on the display screen, attached image names are not described on the column applicable to the classification area 152. Further, the fact that the category is unclassified is imparted to defect images positioned inside the coordinates (000010,000020) (000150,000400) of the unclassified image display area 151. Accordingly, in FIGS. 6(a) and 6(b), all the defect images are described as the unclassified. Area attribute information shown in FIG. 6(b) is information stored within the display/analyzing device 203. Further, information of an attached image shown in FIG. 6(b) is not always necessary, but it will suffice that at least the

classification area and the attribute (category) of the area are recognized.

Next, a typical defect image indicative of the characteristic of the classification area 152 is moved from the unclassified image display area 151 to a typical defect display area 402 as shown in FIG. 7(a) (Step 307). For example, the corresponding defect image present in the unclassified image display area 151 is clicked by a mouse, and moved to the typical defect display area 402 by a drag and drop. In this case, in area category information shown in FIG. 7(b), a moved defect image IMG001 is described in the column of the area coordinates (000160, 000020)(000220,000100), category "white". Alternatively, it is natural that the actual defect image is not moved from the unclassified image display area 151, but a schematic image may be displayed. In this case, a plurality of schematic images as desired are produced in advance, and the thus produced images may be introduced into the typical defect display area 402. Alternatively, also, the typical defect image or images are not displayed on the typical defect display area 402, but text information representative of the features may be displayed.

Then, similar unclassified defect images are classified from the unclassified image display area 151 into the classification area 152 while referring to typical defect images displayed on the typical defect display area

402 (Step 308). For example, the applicable defect image present in the unclassified image display area 151 is clicked by a mouse, and moved to the classification area 152 by a drag and drop. In FIG. 8, defect images IMG005 and IMG010 are classified. Similarly, the classification areas 153, 154, 155 are defined as shown in FIG. 9, and unclassified defect images similar to the typical defect image are classified from the unclassified image display area 151 to the classification areas 152, 153, 154, 155 whereby the classification operation with respect to all the defect images is carried out. FIG. 10 is a display screen showing the classification results. While in this case, four kinds of classification areas were provided for classification operation, it is noted that the contents and the number of the categories are changed as necessary.

Next, a data format shown in FIG. 11 is produced from the classified results shown in FIG. 10 (the data format shown in FIG. 4 is updated), and transmitted from the display/analyzing device 203 to the storage unit 202 (Step 309). For example, corresponding attribute information is obtained from a position on the display screen on which the defect image is arranged on the basis of the area attribute information shown in FIG. 6(b) at a fixed timing after completion of the classification operation or during the classification operation, and a classification category shown in FIG. 11 is updated. Also

in this case, the classified result per wafer unit is transmitted.

Since as described above, the classification area for classifying the defect images is provided on the screen, and the typical image is displayed on the screen, even if when the detected defect images are classified, a plurality of defect images having a complicated shape should be displayed, the user will suffice to merely move the defect images to the optimal classification area showing similar visual features, thus enabling execution of the classification operation easily and quickly. In particular, since the classification operation can be done by a drag and drop using a mouse on the screen, the classification operation can be carried out while looking at all the defect images on the display screen, and the classification operation can be performed while relatively comparing all the defect images to provide an extremely excellent operativity.

Next, an example will be described in which unclassified defect images are automatically classified, and the classified results are corrected to classify the defect images. The automatic classification and the correcting function are combined so that the defect images are roughly automatically classified, after which correction is added, whereby it is possible to shorten the operating time of the classification operation and to

enhance the classification accuracy. FIG. 12 shows a processing flow thereof.

A plurality of classification areas are preset for automatic classification. For example, classification areas 152 to 155 are prepared in the procedure similar to that as described previously as shown in FIG. 13. Also in this case, the classification areas displayed on the display screen are related to the attributes thereof. The area attribute information is stored in a display/analyzing device 203.

Further, functions for automatic classification are stored in the display/analyzing device 203. This function is provided to calculate to which category the features of the defect image belongs. FIG. 14 schematically shows the functions. This represents the function between an area of the defect image and the gray-scale value thereof and calculates at which area the features of the defect image is positioned in the figure. For example, if the feature is positioned in a certain position relative to (tA, uA) as a center, the defect image thereof is calculated as a category A. While FIG. 14 shows a secondary function of the area and the gray-scale value, it is to be noted that other parameters may be used, or multifunction such as cubic or quadratic may be used.

Next, the display/analyzing device 203 obtains the detected result shown in FIG. 4 from the storage unit 202

and displays the detected defect image on the unclassified image display area 151 (Step 1201). The processing until the display/analyzing device 203 displays the detected defect image on the unclassified image display area 151 is similar to that of the example previously mentioned, the detailed description of which is omitted.

Next, the automatic classification starts on the defect image displayed on the unclassified image display area 151 (Step 1202). That is, category under which the feature of each defect image falls is calculated on the basis of the function stored in the image detecting device 201 (Step 1203).

When the category is calculated, the defect image is moved to the corresponding classification area on the display screen on the basis of the aforementioned area attribute information (Step 1204). FIG. 15 is a view showing a display screen after movement. With respect to the defect image that cannot be subjected to image processing according to the picking up conditions to fail obtaining the features, or the defect image which does not fall under any category, the defect image is moved from the unclassified area to a specific classification area manually using a mouse or a keyboard for classification operation.

In the case where the classification for all the images is completed (Step 1205), the classified result is

confirmed (Step 1211), and whether or not the classified result is corrected is judged on the screen (Step 1212). The correction of the classified result is shown in FIG. 15. In FIG. 15, in the case where a defect image A is corrected in category from a classification area 155 to a classification area 153, for example the defect image A present in the classification area 155 is clicked by a mouse (Step 1206) to move the corresponding classification area 152 by a drag and drop, thus enabling easy correction of the classified result (Step 1209). Alternatively, in the case where no corresponding category is present, a category may be newly added (Step 1208).

The aforementioned processing is carried out on all the defect images to complete the classification operation (Step 1210). FIG. 10 shows a display screen showing the corrected result. When the classification operation is completed, category information about the defect images is updated (Step 1213), and the updated result is transmitted to the storage unit 202. In the case where the automatic classification is not completed for all the defect images, that is, in the case where defect images that cannot be automatically classified are present (Step 1205), the procedure is shifted to the classification operation by way of manual classifications shown in Steps 206 to 212.

Since also in this embodiment, the corresponding category information is obtained from the position on the

display screen on which defect images are arranged in accordance with the area attribute information stored in advance, the correction of the classification category for the defect image can be carried out easily. In other words, since the corresponding category information is obtained from the position on the display screen on which defect images are arranged, even if a correction or the like should occur, the user will suffice to merely move the defect image on the display screen, and the classification operation including the correction can be realized very easily, enhancing a convenience in use.

Finally, an analyzing example using the above classified results will be explained below.

In analyzing the classified results, the applicable classified result is obtained from the storage unit 202 in the display/analyzing device 203. FIG. 16 shows one example of analyzing screens thereof. Numeral 1601 designates a position of the detected defect image from the classified results shown in FIG. 11, showing a defect distribution on the wafer. Numerals 1602 and 1603 designate the defect images on the wafer, the imaging conditions and the like. Numeral 1604 designates a classification result display area, in which the classified results relative to the applicable defect images are collected on the spot to display the results thereof. For example, the number of occurrences and the rate of

occurrence according to categories are calculated from the classified results shown in FIG. 11 and displayed.

Although not shown, further, a specific category is selected whereby defects on a wafer with the category are shown understandably according to colors on the position 1601. Here, defects of applicable categories are extracted using the classified results shown in FIG. 11, and the positions of the defects on the wafer are extracted to enable the display of the positions by colors as desired.

Although not shown, alternatively, the classified results may be displayed by a circular graph, a broken-line graph or a bar graph according to categories. These displays may be output to separate windows or may be displayed simultaneously on the window. Further, these may be printed out for the purpose of making reports, or data may be output to files or the like.

The cause of occurrence of the defects is investigated using such a classified result as described to measure the production line early, thus enabling prevention of lowering of a yield of the production line. Accordingly, it is possible to shorten the feedback time of the analyzed results to the production line including the time of classification operation to prevent the lowering of a yield the production line.

According to the present invention, the efficiency classification operation is realized by improving a

user's interface, thus enabling the shortening of the analysis time and the enhancement of the analysis accuracy.